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Original Article

Performance of pheromone traps at different heights for mass trapping of *Helicoverpa armigera* (Noctuidae: Lepidoptera) in chickpea field

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Abstract

Gram pod borer, *Helicoverpa armigera* (Hubner) is one of the essential insect pests which inflict heavy crop losses. The performance of pheromone traps against pest in chickpea field for mass trapping at different heights (2', 4' & 6') was tested at Pulse section ARI Tando Jam. Each height of trap was replicated three times with experimental units of nine traps in area of 1080 square feet. The result regarding moth catches at different height of sex pheromone traps and dates in chickpea field was observed significantly different. Overall, the highest moth population was in the month of February (2.67±1.76). A maximum mean number of moths (36.33±5.17) were observed at 6' height. The results also showed +ve correlation (r=0.601) between larvae and moth and with temperature and relative humidity (r=0.420; r=0.480). The pod damage and larvae were also correlated positively with each other (r=0.820). In addition, *H. armigera* was also captured after harvesting time in fellow land that indicated population of moth also appeared in the absence of host plant but flying ability of moths reduced and most of moths captured at 4 feet (10 moths). Flight ethology of moth was recorded during three different periods of the day. Only few moths (0.3-1.3) captured in day time and most at sunset time (15.3±2.3). Thus, the present results assumed that the pheromone traps are ideal way to monitor the pest population and such traps should be installed at 6' height during cropping season and 4' after harvesting in order to control larvae those pupate inside the soil.

Keywords: *Helicovera armigera*, Sex pheromone, Trap height, Chickpea

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Introduction

Gram pod borer, *Helicoverpa armigera* (Hubner) is very destructive insect pest which inflicts heavy losses through out the cropping season and reach at peak during the appearance of pod (Mehta and Singh, 1983; Deka et al., 1989; Lal, 1996; Sharma et al., 2012). Due to its attack, 75-90% yield losses have been reported. The pest has been controlled mainly with application of different synthetic insecticides which is commolly applied because of their effectiveness and friendly usage (Rakesh et al., 1996). However, the continuous use of similar pesticides, pest has already shown and developed resistance (Ahmad et al., 1995; Sarwar et al., 2009; Kumar and Kumar, 2015). Their regular application also created unsuitable environment for birds, natural enemies and pollinators. In such pollution creating, there is a need to search for better alternate that could replace number of pesticide application. An introduction of certain behavioral chemicals that could initiate in shape of sex pheromones would be an ideal tool to check and reduce the population of gram pod borer.

Synathetic sex pheromone traps are more effective for a long time as compared to insecticide (Rawat et al., 2017). These traps play an essential role being a sampling tool as well control method. It has been observed that these pheromone traps can be very handy for monitoring periodic activity including migration and reproduction of different insect pest species (Tamhankar et al., 1989; Singh and Sachan, 1991; Patil et al., 1992; Sonkar et al., 2012). There are different designs, models and shapes of these pheromone traps according to pest species and their usage. Such as pheromone baited traps, delta trap and funnel trap all could be efficiently used in monitoring the pest population so that chemical can be apllied before economic injury level of pest (Vakenti and Kadsen, 1976; Larrain et al., 2009). However, the design of traps, trap density and trap placement could also play an imperative role to attract the insecst and can be modified from one location to other depend on crop canopy and pest and field conditions (Srinivasan, 2008). Therefore, the present research has been attempted i to monitor the pest population (*H. armigera)* from chickpea field. The investigation on the fieled studies on chickpea pod borer by sex pheromone traps was carried out

Material and Methods

Place of work

The experiment was conducted in the field of Pulse Section, Agriculture Research Institute, Tandojam, Sindh, Pakistan during 2017-2018.

Preparation of funnel pheromone traps

The traps were prepared locally and sex pheromones were purchased from Shani Enterprise, Multan, Punjab, Pakistan. In preparation of funnel traps, the empty plastic jars, funnels, iron wire, plastic lids, small aluminum hook, adhesive tape and wooden bar of different heights were purchased from market those assembled later to prepare the traps (Fig. 1).

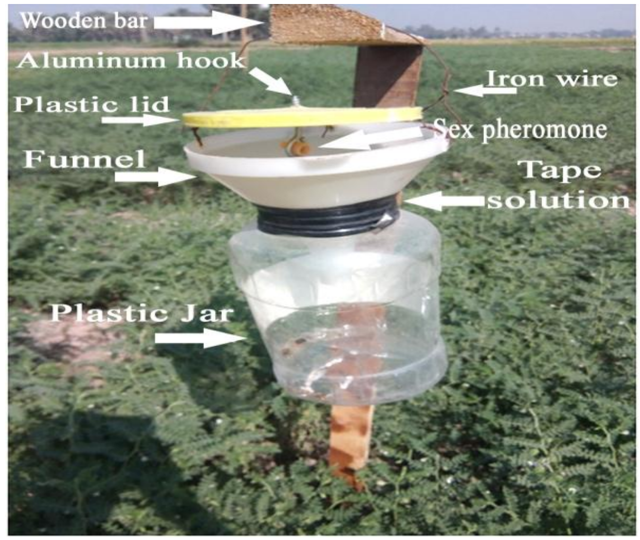

Figure-1: Handmade Funnel type pheromone trap

The height of wooden bars were selected 2, 4 and 6 feet respectively in 7-shaped structure (Fig. 2). The implementation of these handmade pheromone traps in chickpea field was carried out after one month of sowing dates or when pest (larvae) arrived at ETL level.The lures were fixed in aluminum hook and replaced after each 15 days. The composition of these sex pheromone was (Z)-11- hexadecenal and (Z)-9-hexadecenal in 97:3 ratio. The plot size was 300 x 36 sq. feet and each replication size was 100 x 12 sq feet. Furthermore, the pheromone traps were also fixed even after harvesting of crop in similar order to catch the moths for a month.

Figure-2: Instalation of handmade funnel type pheromone trap at different heights (2, 4 and 6 feet)

Experimental design

The data were observed by counting the number of trapped moths and larval population with pod damage at weekly basis and later correlated to know their relationship with weather parameters (temperature and humidity). For larvae and number of pods, five rows per plot and five plants per row were randomly observed. In addition, post harvesting population of moth with similar procedure was also observed with pheromone traps of different heights. The flight ethology in respnonse of pheromone trap was also recorded as mentioned by Rao et al. (1991). Three phases of the day (morning, afternoon and evening) were also selected and traped moths during these phases were recorded for consective seven days.

Statistical analysis

The experiment was carried out in Randomized Complete Block Design (RCBD) with three treatments (heights) those replicated thrice. The data were statistically analysed using ANOVA (analysis of variance) test. The obtained means were separated with significant difference using post hoc test Fisher's least significant difference (LSD) at 0.05 probabilities. All statistical operations were carried out through software Statix 8.1.

Results

The results regarding moth catches of *H. armigera* at different height of sex pheromone traps (Fig. 3) and dates in chickpea field was observed significant different ($P<0.05$) as mentioned in (Table 1). There was no imperative population of moths recorded during first fortnight of observing dates at any traps; meanwhile moths started to trap from 20th, January 2018. Later, the moth population remained captured more or less in pheromone traps. During chickpea season, the overall higher moth population was caught in pheromone traps during the month of February particularly with maximum mean number of moth (2.67±1.76) was trapped on 5th February 2018. At 6 feet height, the maximum 6.00 ± 2.51 moths during February and minimum 0.33 ± 0.33 moths during January were trapped. At 4 feet height, the maximum 2.00 ± 1.52 moths and minimum 0.33 ± 0.33 moths with similar pattern of dates were trapped. However, only two times on different dates with maximum and minimum (0.33 ± 0.33) number of moths were trapped at 2 feet height.

The overall maximum mean number of moth population (36.33 ± 5.17) was observed at 6 feet height followed by 4 feet height (9.33 ± 0.88) and minimum (0.66 ± 0.33) at 2 feet height of pheromone traps (Fig. 4). These results showed that 2 feet height was not appropriate for mass trapping of *H. armigera* during the cropping season.

Table-1: Datewise mean population of *H. armigera* during chickpea season 2017-18

Date	2 feet	4feet	6feet	Mean±S.E
20/01/2018	0.00 ± 0.00b	0.33 ± 0.33bc	0.67±0.67cd	0.33±0.19cd
24/01/2018	0.00 ± 0.00b	0.00 ± 0.00c	0.33 ± 0.33cd	0.11±0.11cd
28/01/2018	0.00 ± 0.00b	0.33 ± 0.33bc	0.67±0.67cd	0.33±0.19cd
01/02/2018	0.00 ± 0.00b	0.33 ± 0.33bc	0.67±0.67cd	0.33±0.19cd
05/02/2018	0.00 ± 0.00b	2.00±1.52a	6.00±2.51a	2.67±1.76a
09/02/2018	0.00 ± 0.00b	0.66±0.33bc	3.66±2.33abcd	1.44±1.12abcd
13/02/2018	0.00 ± 0.00b	0.66±0.66bc	4.00±0.673.05abc	1.55±1.23abc
17/02/2018	0.00 ± 0.00b	1.33±0.33ab	1.00±0.57bcd	0.77±0.40bcd
21/02/2018	0.00 ± 0.00b	1.00±0.57abc	3.33±2.84abcd	1.44±0.98abcd
25/02/2018	0.33±0.33 a	0.66±0.33bc	4.66±1.45ab	1.88±1.39ab
01/03/2018	0.00 ± 0.00b	0.00 ± 0.00c	1.00±1.00bcd	0.33±0.33cd
05/03/2018	0.00 ± 0.00b	0.33±0.33bc	1.33±0.88bcd	0.55±0.40bcd
09/03/2018	0.00 ± 0.00b	0.66±0.33bc	2.33±0.88abcd	1.00±0.69bcd
13/03/2018	0.33±0.33a	1.00±0.57abc	1.66±0.88bcd	1.00±0.38bcd
17/03/2018	0.00 ± 0.00b	0.00 ± 0.00c	1.00±0.57bcd	0.33±0.33cd
21/03/2018	0.00 ± 0.00b	0.00 ± 0.00c	2.00±1.00bcd	0.67±0.67bcd
25/03/2018	0.00 ± 0.00b	0.00 ± 0.00c	1.00±0.00bcd	0.33±0.33cd
29/03/2018	0.00 ± 0.00b	0.00 ± 0.00c	1.00±0.00bcd	0.33±0.33cd

Means followed by different letters within the same column are significantly different ($p < 0.05$)

Figure-3: The moth catches of *H. armigera* at different pheromone traps heights

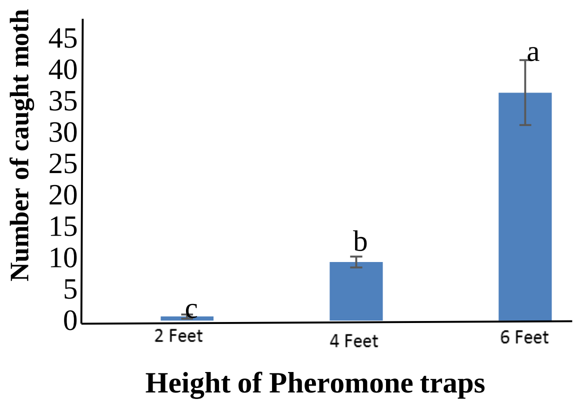

Figure-4: Mean Population *H. arimgera* at different heights of pheromone traps
Means represent by different letters in bar diagram are significantly different (p <0.05)

Furthermore, population of larvae and moth were correlated with each other, that it showed positive correlation (r = 0.601, p<0.05) with highly significant difference moth. Date showed positive but lowest correlation with non-significant difference (r=0.28, P>0.05). larvae and date showed positive correlation with non-significant difference (r=0.433, P>0.05), date and pod damage showed positive and hightest correlation with significant difference (r=0.876, P<0.05), date and temperature (r=0.93, P<0.05), date and relative humidity (-0.399, P<0.05), pod damage and moth (0.303, P>0.05), moth and temperature (r=0.15, P>0.05), moth and relative humidity (r=0.151, P>0.05), larvae and pod damage (r=0.540, P<0.05), larvae and temperature (r=0.303, P>0.05), larvae and relative humditity (r=-0.162, P>0.05), temperature and relative humidty (r=-0.378, P>0.05), respectively (Table 2).

Flight ethology of *H. armigera* in response of pheromones was recorded during three different periods of the day (morning, afternoon and evening) for consecutive seven days. The results showed statistically different flying time of moth (P<0.05) that executed that the pest has crepuscular behaviour of flight against pheromone traps (Fig. 5).

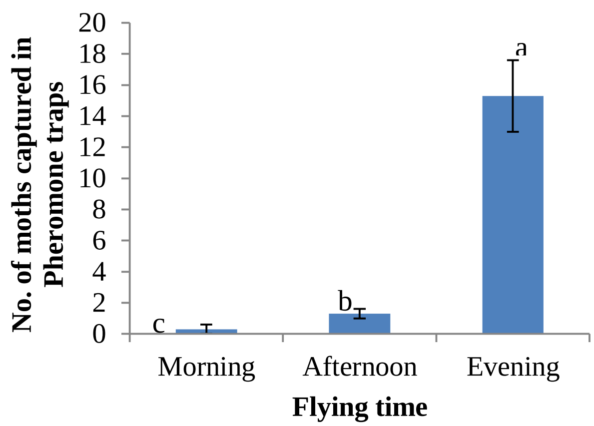

Figure-5: Flying ethology of *H. armigera* towards pheromone traps during different phases of the days
Means followed by different letters in bar diagram are significantly different (p <0.05).

Table-2: Correlation coefficient measured between population of *H. armigera* and environmental factors

	Date	Moth	Larva	Pod damage	Temp	R/H
Date	1					
Moth	0.287*N.S	1				
Lavae	0.433*N.S	0.601**H.S	1			
Pod amage	0.876**H.S	0.303*.N.S	0.540**H.S	1		
Temp	0.937**H.S	0.150*N.S	0.303*N.S	0.796*H.S	1	
R/H	-0.399*N.S	0.151*N.S	0.136*N.S	-0.162*N.S	-0.378*N.S	1

**Highly correlated, * Low/ no corrrelated, N.S= Non-significant, H.S= Highly-significant

However, it can be easily emphasized that only few moths (0.3 to 1.3) captured in day time and most at sunset time (15.3± 2.3 moths). In addition, moths of *H. armigera* were also captured after harvesting time in fellow land as pest pupates in soil and adult could emerge even though in absence of host plant. The results indicated that in absence of host plant, flying ability of moths reduced and most of moths captured at 4 feet (10 moths) with statistical difference ($P<0.05$) followed by 6 feet (6 moths) and lowest at 2 feet (3 moths), respectively (Fig. 6).

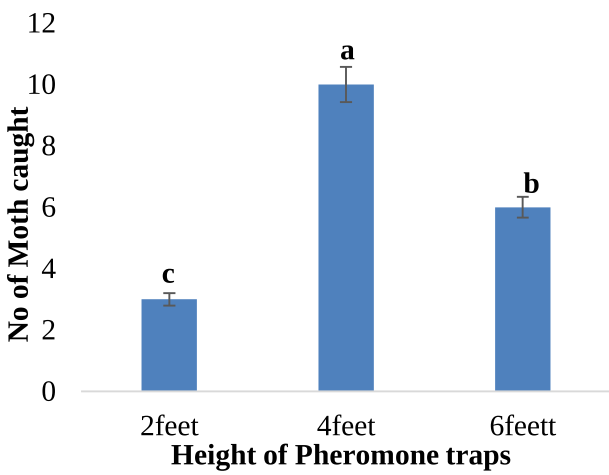

Figure-6: Post-harvest population of *H. armigera* at different height of pheromone traps in chickpea field.

Means represent by different letters in bar diagram are significantly different ($p < 0.05$).

Discussion

Chickpea has been noted to damage by few insect pests but association of *H. armigera* (Hubner) with chickpea is very crucial (Lal, 1996) and often occurs in destructive form. It does huge losses that initiates from seedling and continue till maturity.

Keeping in view the importance of above mentioned scenario, the current research has been carried out as sexual pheromone traps propose an exellent sampling method for winged adult insects as well control method (Tamhankar et al., 1989; Singh and Sachan, 1991; Patil et al., 1992). The study was based on performance of pheromone traps at different height for mass trapping of *H. armigera* (Noctuidae: Lepidoptera). The installation of pheromone traps were executed at different height in chickpea field and the results of sex pheromone displayed that maximum number of moths trapped at 6 feet height during cropping season. Gauthier et al. (1991) conducted similar study on lepidopteron pests and reported that the highest population of adult moths found at the height of 4-6 feet as compared to surface of land. These results executed that 2 feet height was not appropriate for mass trapping of *H. armigera* during the crop season. Survelliance of insect population through installation of pheromone traps has previously been well reported as an essentail advantageous of sex pheromone research. The traps with pheromone baited could be ideally consumed in assessing the pest population as pesticides could be planed at suitable time in order to control pest (Vakenti and Kadsen, 1976). Similarly, funnel traps and delta traps could be used for sex pheromone lures in field conditions. Meanwhile, the design of traps that could attract maximum insects will vary at different location and the traps settlement according to crop canopy could also generate different results (Srinivasan, 2008).

The infestation of *H. armigera* was started to trap from 20th January. Later, the moth population captured more or less in pheromone traps; however, the maximum population was recorded in the month of February. These findings are in accordance with Reena et al. (2009) who reported that *H. armigera* captured in synthetic sex pheromone traps from the month of January and the peak was trapped during the month of February. Similarly, Hossain (2008) also noted peak population of *H. armigera* during the first quarter of the year with highest population in the month of February. Furthermore, the population of larvae and moths were observed synchronized with each other and more or less with abiotic factors like temperature and relative humidity. Similarly, the existence of maximum larval population also displayed the highest number of pod damage. These findings are in confirmation with Anwar and Shafique (1992) who observed that moth population were positively correlated with increasing temperature, larval population and pod damage percentage. Mehta and Singh (1983) and Deka et al. (1989) reported that the losses reached peak when the pods appeared.

Sharma et al. (2012) reported that adult population of *H. armigera* correlated positively with change in temperature and relative humidity. Basavaraj et al. (2013) recorded that association between the synthetic sex pheromone trap captures with climatic parameters was correlated positively and negatively with temperature and relative humidity, respectively. The moth *H. armigera* population at day time was found negative with temperature. Morning and evening time were observed negative and non-significant with adult moth population of *H. armigera* reported by Upadhyay et al. (2009). In addition, it was observed during study that most moths were captured during evening particularly at sun set time. It revealed that pest has crepuscular behaviour of flight against pheromone traps. However, it can be easily emphasized that only few moths (0.3 to 1.3) captured in day time. Moreover, the moths of *H. armigera* were also captured after harvesting time in fellow land as pest pupates in soil and adults could emerge even in absence of host plant. The results indicated that in absence of host plant, flying ability of moths reduced and most of moths captured at 4 feet. Present findings are confirmed with the findings of various researchers who also described the flying behavior of lepidopteron moths in evening and night and one of the most common reason was light (Patil and Mamadapur 1996; Shivakumara, 2001).

Shivakumara (2001) and Nagaraja et al. (2006) reported that the correlation between captured moths and evening time was noted positively. Sinha and Jain (1992) collected more adult moths through pheromone traps during cool weather on chickpea field. Similar results were described by Patil et al. (1992) on cotton crop. Mall et al. (1992) and Satpathy and Mishra (2007) also reported that adult of *H. armigera* were active at evening and their favorable temperature is 20-25^{0}C.

Conclusion

It is concluded from the observed results that the sex pheromone traps in chickpea field should be installed at 6 feet height starting from the month of February. In addition, these traps should remain in the harvested field for at least one month to capture the moths that could emerge from pupation inside the soil.

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Contribution of Authors

Ujjan RL: Conducted all research work during his post-graduation.
Ahmed AM: Supervised post graduate students and presented main research idea regarding this research work.
Alhilfi AZA: Helped in recommending Pheromones
Khoso FN: Helped in recommending different heights of traps and design
Rahoo AM: Helped in providing agriculture land for performing experiment work, experimental designing and layout
Rajput IA: Helped in analysis statistics data
Soomro DM: Helped in preparing this manuscript and data analyzing